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A Virtual Reality Applications Facility for Visualization of Joint Battlespace

Final Performance Report

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**Virtual Reality Applications Center
Iowa State University**

October 4, 2002

1.0 Introduction

The Virtual Reality Applications Center is an interdisciplinary research center administered by the Institute for Physical Research and Technology at Iowa State University. VRAC has become a national leader in the increasingly important field of applications of virtual reality to the challenges of engineering and science.

Objective

The objective of this project was to support command and control embedded training research and development. This effort focused on development of embedded training in a training environment for operational command and control systems. This environment combines live, virtual, and constructive entities, allows war fighters to train individually or collectively at all levels of war, and provides, on demand, realistic training opportunities for command and control operators that mimic the operational environment.

The agreement with ISU was to utilize the C2/C6 facilities at the VRAC to integrate existing DoD simulation training software and collect training effectiveness research data on command and control performance.

The immediate advantages that we expected to realize in connection with the research was that the C2 (now C4) would be a flexible test bed that could be rapidly and inexpensively modified for multiple missions as well as customized for any special or nonstandard mission rehearsal. Additional benefits include the ability to connect the C4 facility to the C6 facility for Virtual Reality (VR) based collaborative training and 3D debriefing for auditorium audiences. These capabilities are directly applicable to the training requirements of the 133ACS in Fort Dodge, Iowa.

Our proposal was for the purchase of equipment to upgrade the VRAC C2 facility to a flexible configuration along with updated projector and visual display equipment. The ability to configure the C2 facility according to the application requirements represented a significant advance in fully immersive virtual reality capability for DoD mission training objectives.

Final Progress

We opened the new flexible system May 2002 for use in researching virtual reality and collaboration. The "immersive projection" system can create a viewing area as large as 36 feet wide and 9 feet tall, about equal to the display area of 380 standard 17-inch computer monitors. Called the C4, the facility replaces the center's C2 system built in 1996. Like its predecessor, the C4 can also be made into a 12-by-12 foot room with images projected onto three walls as well as the floor. The C4 environment has better, brighter projectors and, within a matter of minutes, we can reconfigure it into one of the largest 3D projection screens in the world. This greatly expands the types of applications we can run.

The system was designed and built in cooperation with Mechdyne Corporation, [of Marshalltown, Iowa. Mechdyne, which has become one of the world's leading suppliers of virtual reality and visualization systems, with a client list that spans six continents and includes

several Fortune 100 and 500 companies. The C4 is driven by high-performance computers from SGI. Because space is limited, images from the projectors are reflected off two mirrors before reaching the screens, a method known as "folded optics." To enable the walls to be swung in and out, projectors are mounted on supports connected to the wall framework. The project also required extensive renovation of the facility, which formerly housed wind-tunnel equipment.

VRAC uses several immersive environments, the largest and highest immersion of these environments are the C4, the C6, and the Lee Liu Auditorium. (see WWW.vrac.iastate.edu.) The C4, C6 and the auditorium systems all project "stereoscopic" images onto large screens. Using special glasses, these images appear three-dimensional to viewers. A tracking system keeps tables on the user's position and orientation to maintain correct prospective as the user "moves" around a virtual space. Three-dimensional sound adds to the realism of the virtual environment.

The new C4 will be particularly valuable in virtual battlespace studies wherein developing the shape of the immersive area is a key part of the research. This new environment also includes a new tracking system, an Ascension Wireless MotionStar. It reports position and orientation data for a user in the C4 without the user being "tethered" to the computer. The new system includes 16 sensors, meaning that up to 16 body points (or other objectives) can be simultaneously tracked.

Equipment Purchased

The C4 is a second generation CAVE that can be used in the traditional CAVE configuration or be modified to create a viewing area as large as 36 feet wide and 10 feet high. This award of $360,680 was used entirely for the purchase of the flexible screen configuration, virtual reality system (MD-Flex Barco Reality) from the MechDyne Corporation for the new C4.

Research

Researchers at VRAC are working on two major defense related projects applying virtual reality interfaces to improve operational readiness and situational awareness. The first of these projects, sponsored by the Air Force Research Lab's Human Effectiveness Directorate, is a two-year investigation of the use of collaborative computer immersion to recreate a Joint Battlespace. The Virtual Battlespace currently under development is a platform for experimentation to determine the positive impact that immersion can have on battlespace management. The project objective is the development and evaluation of a data synthesis and visualization system for battle managers. The system facilitates multi-user, collaborative interaction between participants at a variety of levels of immersion.

The current phase of the investigation involves the development of a multi-user, collaborative system to allow interaction between participants at a variety of levels of immersion. The system will facilitate simultaneous interaction between multiple participants, playing distinct roles at distinct levels of immersion. Combining a traditional 2D desktop user, a user at an immersive desk, a fully immersed user in the C4 or C6, and a group of from 10-200 users in the VRAC stereo auditorium into a common environment will provide us a test bed to evaluate how levels of immersion can be used to increase task performance in a battle environment. Some initial results of this work have been summarized in a paper presented at this years International

IITSEC conference in Lille, France. (Innovative C2 Training Solutions For Air Force Modular Control Systems, Brooks, Breitbach, George)

The second project is a multi-year collaboration between a VRAC research team, the Iowa National Guard and the Iowa Technology Center. The objective of this effort is to investigate, create and evaluate the use of immersive interfaces as tools to improve the operational readiness of Iowa National Guard staff, both Army and Air. Working with domain experts assembled by the Guard and the Iowa Technology Center, Iowa State University (ISU) is leveraging the considerable hardware, software and intellectual resources of ISU's Virtual Reality Applications Center (VRAC) to develop immersive training applications that provide Iowa Guard personnel with a greater breadth and depth of situational experience than would be possible without simulation. Using state of the art computer visualization, ISU is showing how the next generation of human-computer interfaces can be incorporated as an integral and effective component of the system for preparing Iowa Guard personnel for their role in the warfighting machine of the coming decades. The effort is currently directed towards training in the area of command and control, providing Iowa Guard personnel with comprehensive and flexible training simulations. The result will be more realistic training that is cost effective.

Summary

The purchase of the flexible screen configuration helped bring the C4 on line in May 2002. Since that time, work with the C4 and the other VRAC immersive environments have increased to provide support for a wide range of ongoing work, including exciting and innovative defense contracts.

We are grateful to AFOSR for their continuing support.

Appendix

Ongoing Research Projects

Sponsor	PI	Term	Title	Co-PIs
Air Force Research Lab (AFRL/IFB)	James Bernard	8/21/2000 to 12/31/2002	Visualization of the Joint Battlespace	C. Cruz-Neira; H.-A. Pham
Alliant Energy	Kenneth M. Bryden	8/15/2000 to 8/14/2003	Computational Modeling of a Tangentially Fired Pulverized Coal Furnace: Phase 2	
Alliant Power	Kenneth M. Bryden	11/1/1998 to 12/31/1999	Computational Modeling of a Tangentially Fired Pulverized Coal Furnace: Phase I	
Cornell University (NSF)	Carolina Cruz-Neira	10/1/1999 to 9/30/2002	A Two-tier Computation and Visualization Facility for Multiscale Problems	
Deere & Company	James Bernard	11/1/2001 to 10/31/2005	Synthetic Environments as Enabling Technology for Product Development: Phase 3 (continuation)	K. M. Bryden; D. Cook; C. Cruz-Neira; J. Dickerson; A. Kelkar; G. Luecke; J. Vance
Deere & Company	James Bernard	11/1/2001 to 10/31/2002	Synthetic Environments as Enabling Technology for Product Development: Phase 3	K. M. Bryden; D. Cook; C. Cruz-Neira; J. Dickerson; A. Kelkar; G. Luecke; J. Vance
Department of Energy	Kenneth M. Bryden	10/1/1999 to 9/30/2002	Development of Virtual Power Plants	
Fuel Tech, Inc.	Kenneth M. Bryden	8/15/2001 to 8/15/2005	Development of Rapid Solutions for Reacting Flows	

			Learner Connections in Biotechnology: Virtual Bioprocess	
Indian Hills Community College (NSF)	Kenneth M. Bryden	8/15/2001 to 6/30/2004	Learner Connections in Biotechnology: Virtual Bioprocess	
Iowa Department of Public Defense	Adrian Sannier	4/1/2001 to 3/31/2003	Military Applications of Immersive Environments	J. Bernard; C. Cruz-Neira
ISU-Special Research Initiation Grants Competition	Anne Deane	1/1/02-12/31/02	Ashes to Ashes Driving Project	C. Cruz-Neira
John Deere Foundation	Judy Vance	4/6/2001 to 4/5/2003	John Deere Foundation Gift	
National Science Foundation	Chan, Chiu-Shui	1/1/2001 to 12/31/2003	Utilizing Three-Dimensional Data in a Virtual Urban Environment to Support and Evaluate Planning Decisions	C. Cruz-Neira; R. G. Mahayni; D. Shinn; I.-S. Suen
National Science Foundation	Dianne H. Cook	10/15/1999 to 9/30/2002	Interactive and Dynamic Visual Overviews of Large Multi-Dimensional Data	V. Honavar; L. Miller
National Science Foundation	William Gallus	11/1/01-10/31/03	A Virtual Tornadic Thunderstorm to Enable Student-Centered Learning About Complex Storm-Scale Atmospheric Dynamics	C. Cruz-Neira; C. Cervato
National Science Foundation	Judy Vance	8/1/1996 to 7/31/2002	REU: A Career Development Plan: Research and Teaching	
National Science Foundation	Judy Vance	8/15/1996 to 7/31/2002	A Career Development Plan: Research and Teaching	
National Science Foundation	Judy Vance	10/1/2000 to 9/30/2003	Interactive Product Development in a Virtual Environment Utilizing Haptics	

National Science Foundation	Judy Vance	8/1/2001 to 9/30/2003	Interactive Product Development in a Virtual Environment Utilizing Haptics (RET)	
National Science Foundation	Julie Dickerson	1/1/2001 to 12/31/2003	Wireless Multimedia Communications for Virtual Environments	D. Rover; C. Cruz-Neira; R. Weber
National Science Foundation	William Gallus	2/1/2002 to 1/31/2003	A Virtual Tornadic Thunderstorm to Enable Student-centered Learning About Complex Storm-Scale Atmospheric Dynamics	C. Cruz-Neira; C. Cervato
Procter & Gamble Company	Dan Ashlock	8/3/2000 to 12/31/2002	Bioinformatic Tools for Extraction and Modeling of Signal Transduction Networks	D. Berleant; J. Dickerson; R. Maddux; E. Wurtele
Procter & Gamble Company	Judy Vance	2/1/2002 to 1/31/2003	Exploration of Finite Element Analysis Data in a Virtual Environment	
University of Iowa/NADS	James Bernard	8/1/2000 to 9/30/2002	Advanced Simulator Networking for Vehicle and Equipment Distributed Product Design	C. Cruz-Neira; K. M. Bryden
US Dept. of Energy	Kenneth M. Bryden	6/21/2001 to 9/30/2004	Multi-Component Harvesting Equipment for Inexpensive Sugars from Crop Residues	F. Battaglia
Winegard Company	Greg Luecke	4/28/2001 to 4/27/2002	Analysis and Implementation of a Tracking Mobile Television Receiver (continuation)	